

Science Olympiad 2015 – BCS Cobra Invitational - Jan 24, 2015

Simple Machines

Team #: _____

Team Name: _____

Use precision of up to 1-2 decimal digits.

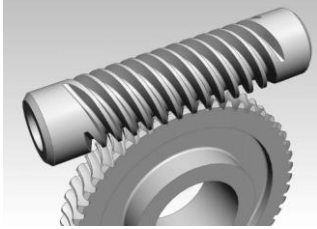
1 point each. (Total 50)

1. Simple machines perform following:
 - A. Multiply the force
 - B. Multiply the distance
 - C. Change the direction of the force
 - D. None of the above
 - E. All of the above
2. The tendency of a force to cause an object to rotate around an axis is called
 - A. Friction
 - B. Turn
 - C. Torque
 - D. Track
 - E. None of the above
3. Staircase is an example of which type of simple machine
 - A. Wedge
 - B. Lever
 - C. Inclined plane
 - D. None of the above
4. Which of these levers does not change the direction of force? Select all that apply.
 - A. First-Class lever
 - B. Second-Class Lever
 - C. Third-Class lever
 - D. None of the above
5. A machine is a device that does one or more of the following three things; makes work easier, makes work faster, or _____.
 - A. uses a force
 - B. is a push or pull
 - C. includes one of the simple machines
 - D. changes the direction of the effort
6. What type of simple machine is a diving board in a pool?
 - A. First Class
 - B. Second Class
 - C. Third Class
 - D. Fourth Class
7. To reduce the effort required to split firewood, a wedge can be used. To minimize the effort required, the thickness of the wedge should be:
 - A. Decreased as much as possible
 - B. Bigger than the length of the wedge
 - C. Increased with the length
 - D. Made of a rubber material
 - E. Left the same.
8. The ratio between the Ideal Mechanical Advantage (IMA) and the Actual Mechanical Advantage (AMA) is generally known as _____ and is caused by _____.
 - A. Friction, Efficiency
 - B. Noise, Efficiency
 - C. Efficiency, Friction
 - D. Friction, Gear
 - E. None of the above
9. With a force of 100 N you push a second class lever up 20 cm in 40 seconds, your power output is
 - A. 1 W
 - B. 1/2 W
 - C. 4 W
 - D. More than 4 W
10. A machine has an ideal power output of 1000 W and an actual power output of 800 W. The mechanical efficiency of the machine is?
 - A. 80 %
 - B. 125 %
 - C. 20 %
 - D. 25 %
11. If a load of 200 N is to be lifted 2m by a block and tackle, how much work do we save by using a block and tackle?
 - A. 25 J
 - B. 10 J
 - C. 15 J
 - D. 0 J
12. A basketball hoop is a simple machine
 - A. True
 - B. False

13. If you are trying to push a wagon filled with bricks, the hardest part will be getting it started. Once it's moving it will be easier to push. This happens because of :

- A. Friction
- B. Potential energy
- C. Kinetic energy
- D. Inertia

14. What type of gear is shown in the following diagram?



- A. Pinion and Sector
- B. Worm
- C. Rack and Pinion
- D. Spur

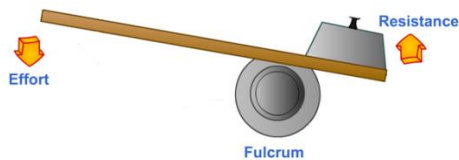
15. Inclined plane produces a mechanical advantage

- A. by decreasing the distance through which the force must move
- B. by increasing the distance through which the force must move
- C. None of the above

16. Torque is a _____ quantity.

- A. Scalar
- B. Vector
- C. Scalar and vector
- D. None of the above

Refer to diagram below to answer the next 4 questions



17. The mechanical advantage of the above lever is 10:1. How much **mass** in kg must be placed on the effort end to balance a resistance **mass** of 1000kg?

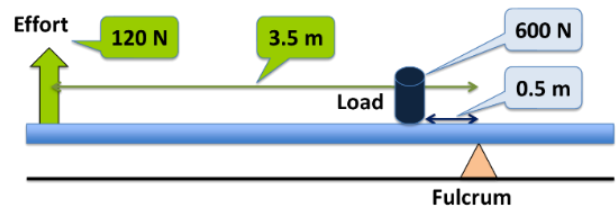
18. How much Force is applied in the above case on the effort end of the lever?

19. Using the effort mass calculated above, What distance should the effort mass move to raise the 1000kg resistance mass a distance of 4 cm?

20. How much Work is done in the above case on the effort end of the lever?

21. If the total length of the lever is 1.1m, what is the effort length of the lever?

Refer to the diagram below for the next 3 questions



22. Calculate the Ideal Mechanical Advantage (IMA)

23. Calculate the Actual Mechanical Advantage (AMA)

24. Calculate the Efficiency

25. A toy car has a wheel and an axle. If the axle is 50mm in diameter and the wheel has a radius of 10cm what is the mechanical advantage of this wheel and axle?

26. Given an efficiency of 97%, what is the Actual Mechanical Advantage for the wheel and axle in previous question?

Refer to the diagram to the right below for the next 3 questions



27. What is the mechanical advantage of the pulley system shown to the right?

A. 3
B. 4
C. 5
D. None of the above

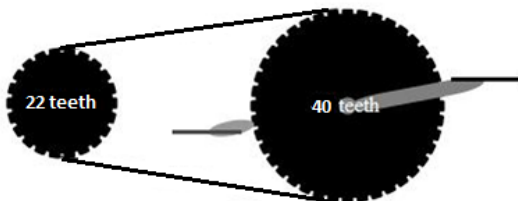
28. How much effort is required to lift a load of 100 N

A. 50 N
B. 33.3 N
C. 25 N
D. 20 N

29. If you pull 4m of the rope, how far did the load move?

A. 5m
B. 2m
C. 1m
D. 0.8m

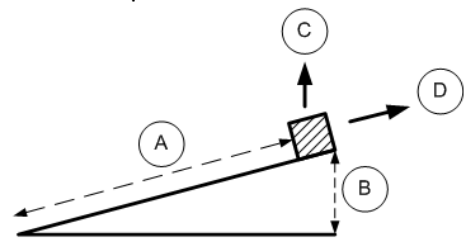
Refer to the gear drive in a bicycle in the diagram below to answer the next 2 questions



30. What is the gear ratio of this gear system

31. If pedal gear makes 12 rotations, how many rotations will the driven gear make?

Picture below depicts an inclined plane 4 m long is used to lift a piano weighing 1500 N onto the back of a truck 2 m off the ground. A force of 900 N was needed to push the piano up the inclined plane. Answer questions 32-41.



Word bank

- Effort distance ● Resistance Force
- Resistance Distance ● Effort force

32. Label A _____

33. Label B _____

34. Label C _____

35. Label D _____

36. What was the work in?

37. What was the work out?

38. What was the IMA of the inclined plane?

39. What was the AMA of the inclined plane?

40. What was the efficiency?

41. If 1200 J of work is input into this same machine, how much work will be output by the machine?

42. Can a machine be useful if its mechanical advantage is less than one? Explain and give an example.

43. The Great Pyramid is 146m high. How long would a ramp from the top of the pyramid to the ground need to be to have an IMA of 4?

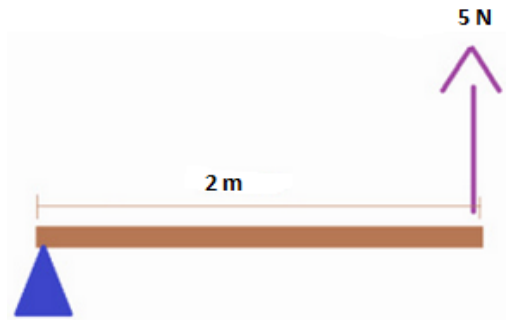
44. The rear wheel of a bicycle has a radius of 38.5 cm and has a gear with a radius of 4.75 cm. When the chain is pulled with a force of 175 N, the wheel rim moves 18.0 cm. The efficiency of this part of the bike is 95.0 percent. How far was the chain pulled to move the rim that amount?

- A. 1.45 cm
- B. 1.45×10^2 cm
- C. 2.21 cm
- D. 2.12 cm

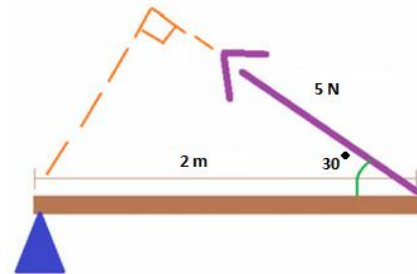
45. A pulley lift raises a 1.14×10^3 -kg car a distance of 2.4 m. If the car is lifted in 47 s, how much power does the lift produce?

- A. 290 W
- B. 58.2 W
- C. 571 kW
- D. 571 W

46. A force of 5.0 N is applied at the end of a lever that has a length of 2.0 meters. If the force is applied directly perpendicular to the lever, as shown in the diagram, what is the magnitude of the torque acting the lever?



47. If the same force of 5 N is applied at an angle of 30 degrees at the end of the 2.0 meter lever, what will be the magnitude of the torque?



A hydraulic shear with an output force of 1000 N is used to shear plate steel to rough size. The shear has a 2 cm thick cutting blade with a 45° degree slope. Answer the next 3 questions.

48. What is the length of the slope?

49. What is the ideal mechanical advantage of the wedge?

50. How much resistance can be overcome by the shearing machine?

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Simple Machines Answer Key

No units no points; answers must be precise without rounding errors; decimals reported in decimals up to 1 or 2 digit precision. No partial points.

1. E
 2. C
 3. C
 4. B & C
 5. D
 6. B
-

7. A
 8. C
 9. B
 10. A
 11. D
 12. B
-

13. D
 14. B
 15. B
 16. B
 17. 100 kg
 18. 981 N or (980.665 N rounded to any precision acceptable)
-

19. 0.4m
 20. 392.4 Nm or J (based on previous answer * 0.4 rounded to at least 1 decimal ok)
 21. 1m
 22. 7
 23. 5
 24. 0.71429 or 71.429 % (rounded to at least 1 decimal ok)
 25. 4
-

26. 3.88
 27. 5
 28. 20 N
 29. 0.8m
 30. 0.55:1
-

31. 21.818
 32. Effort distance
 33. Resistance distance
 34. Resistance force
 35. Effort force
 36. 3600 Nm or J
 37. 3000 Nm or J
 38. 2
 39. 1.67
-
40. 83.5 % or 83.33 % (MA calculation, work calculation respectively)
 41. 1002 or 999.96 Nm or J (using eff % based on MA or Work respectively)
 42. Yes. This happens when a machine is used to increase distance such as a rake, baseball, fishing pole etc.
 43. 584m
 44. C
 45. D
-
46. 10 Nm
 47. 5 Nm
 48. 2.83 cm
 49. 1.415
 50. 1415 N

Questions 48-50 answer image

